

Two New Species of Eulimid Gastropods Endoparasitic in Asteroids

by

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Abstract. Two new species of the genus *Asterophila* Randall & Heath, 1912 (Prosobranchia, Eulimidae) are described, *A. perknasteri* from the Antarctic starfish *Perknaster* sp. (Valvatida, Ganeriidae) and *A. rathbunasteri* from the californian starfish *Rathbunaster californicus* Fischer, 1906 (Forcipulatida, Asteroiidae). A third species of *Asterophila* is reported from *Freyella* sp. (Brisingida, Briseringidae), from the southern part of the Kermadec Trench, but is not described.

INTRODUCTION

The family Eulimidae consists of gastropods parasitic on and in echinoderms. Most species are temporary ectoparasites that spend most of their time hiding in bottom sediment, occasionally taking a meal from a nearby, suitable echinoderm. Such species maintain most of the normal gastropod anatomy. Other species are highly modified endoparasites that spend most of their lives attached inside the host specimen, having only a short free-swimming larval stage during which they find new host specimens. Warén (1984) presented a list of the genera and what was known about the biology of the species of Eulimidae.

Here we describe two new species of *Asterophila* and summarize the present knowledge on the genus, which previously was not easily accessible since it was published in Russian.

MATERIALS AND METHODS

This paper is based on specimens forwarded to Warén from various surveys. The specimens are enumerated under each species, together with the location of the material.

For the description of the parasites and the method of parasitism, the arms of the starfishes were opened cautiously, starting some distance away from the swellings to avoid damaging the parasites. Photographs of selected snails

in situ were taken using WILD M420 macrophoto equipment. A few specimens were stained with karm-alum to contrast the organs of the very pale and featureless bodies. To illustrate certain features, some specimens were critical point dried via acetone and carbon dioxide and photographed with a scanning electron microscope (SEM).

SYSTEMATICS AND DESCRIPTIONS

Gastropoda, Prosobranchia,
Neotaenioglossa

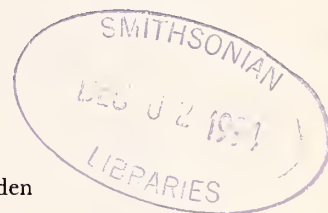
Family EULIMIDAE Philippi, 1842

Asterophila Randall & Heath, 1912

Type species. *Asterophila japonica* Randall & Heath, 1912, by original designation. Parasitic in *Pedicellaster magister orientalis* Fischer, 1928 (Forcipulatida: family Pedicellasteridae) from Japan.

Remarks: Randall & Heath's (1912) description of *Asterophila* is not very detailed, and Grusov's (1965) excellent redescription is in Russian. Therefore we present here a rather detailed introduction to the genus, supplemented by our observations. Until the present time, *Asterophila* has contained only the type species.

Grusov (1965) redescribed *Asterophila japonica* in great



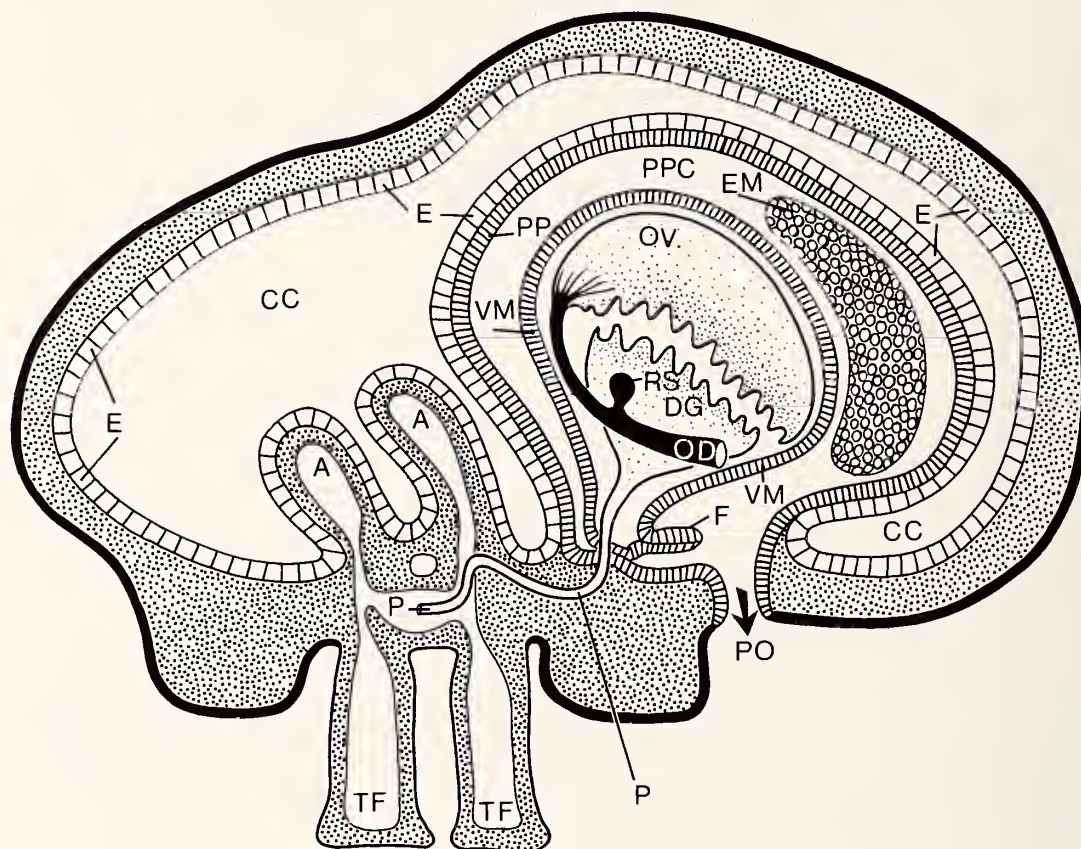


Figure 1

Schematic cross section of an arm of a starfish with *Asterophila* sp. in its body wall (and cavity). The snail has caused an abnormal swelling of the right half of the arm. It is surrounded by the pseudopallium, has a proboscis leading to the radial canal, and its pseudopallial cavity opens to the exterior via a pore, where an arrow marks the assumed exit path for the larvae.

A—ampullae; CC—coelomic cavity of the starfish; DG—diges-

tive gland; E—coelomic epithelium of the starfish; EM—egg mass of the snail in the pseudopallial cavity; F—foot of the snail; OD—glandular oviduct; OV—ovary of the snail; P—proboscis; PO—pore from the pseudopallial cavity; PP—pseudopallium; PPC—pseudopallial cavity; RS—receptaculum seminis; TF—tube foot of the starfish; VM—visceral mass.

detail, based on 600 specimens, several of which were serially sectioned. He recorded *A. japonica* from the Bering Strait to Korea, in 14–700 m depth from several host species: *Ctenodiscus crispatus* (Retzius, 1805) (Paxillosida: family Gonioplectinidae); *Leptychaster* sp. (Paxillosida: family Astropectenidae); *Cribrella* sp. (= *Henricia* sp.) (Spinulosida: family Echinasteridae); *Leptasterias polaris* (Müller & Troschel, 1842); *L. groenlandica* (Lütken, 1857); and *L. arctica* (Murdoch, 1885) (Forcipulatida: family Asteroiidae).

External examination by the senior author of several hundred specimens of *Ctenodiscus crispatus* from Svalbard and northern Norway in the extensive collections of the Swedish Museum of Natural History, gave no reason to suspect its presence there.

Hoberg et al. (1980) found *Asterophila japonica* in the northeastern Bering and Chukchi Seas, in *Leptasterias arc-*

tica and *L. polaris acervata* (Stimpson, 1862), and reported a prevalence between 2 and 60 percent. It is thus known from most of the orders of asterooids. This is unusual for eulimid gastropods, which usually are quite and sometimes very host specific (Warén, 1984). Usually the endoparasitic and permanently attached species exhibit a higher specificity than those that regularly leave the host, which makes this wide range of hosts more surprising.

Stone & Moyse (1985:1270) reported an endoparasitic gastropod from the deep-sea asteroid *Freyella* sp. living in the same specimens as an ascothoracid crustacean, but did not suggest its identity. Examination of the specimens, kindly sent for examination, showed that they belong to *Asterophila*, and they are briefly described (but not named) below. So far no other distributional information has been published on the genus.

Asterophila is a highly modified gastropod, and Figure

1 is a schematic representation of the organization and the position of the female in the host. The male is much smaller than the female, being less than one-tenth of her size. The male is either attached to the pseudopallium of the female or lives in her oviduct.

Young specimens are assumed to start their lives in the body wall of the asteroid, but as they grow, they force the coelomic epithelium to bulge into the coelomic cavity, so that the parasite ends up lying in the cavity, completely covered by the coelomic epithelium. Frequently, one or several ampullae of the tube feet, or other organs of the host, are included in the external cover formed by the coelomic epithelium.

The head and parts of the proboscis (cf. below) of the snail are modified into a large balloonlike wrapping which covers the visceral mass (the so-called pseudopallium) and leaves a large space between the visceral mass and the pseudopallium. Mature specimens use this space for storing the large egg mass which is contained by a thin membrane and is partly wrapped around the visceral mass.

It was not mentioned by Grusov (1965), but judging from the presence of rudimentary tentacles on the inside of the pseudopallium of *A. perknasteri*, the head of the snail contributes to the formation of the pseudopallium. These small bulges were verified as tentacles by following the large nerves which innervate them and which connect directly to the cerebral ganglia. These nerves were mentioned by Grusov (1965:fig. 31, number 13, dorsal pair) together with two more ventral pairs, all called "pseudopallial nerves." The dorsal pair corresponds in position to tentacle nerves in other eulimids, while the two more ventral pairs seem to correspond to the nerves innervating the proboscis sheath ("snout" in Grusov 1965; the real snout is lost or transformed into the proboscis sheath in the least modified eulimids). In the following descriptions, the term "stalk" is used for this part of the snail, formed by the head-foot and constituting a connection between the pseudopallium and the visceral mass. On the stalk can be seen the rudimentary foot. The stalk also contains the central nervous system.

The presence of the rudimentary tentacles facilitates the orientation of the specimens by defining the front of the animal. Posterior to the stalk is a pore through the pseudopallium. This part of the pseudopallium is thickened, more muscular and bulges into the body wall of the host, where it usually causes deformation of the skeletal elements. Frequently there is also a corresponding pore in the body wall of the host, and the pseudopallial cavity is thus in communication with the surrounding sea.

In the center of the stalk runs the esophagus. Distally to the pseudopallium the esophagus continues inside the proboscis sheath, which also is formed by the hypertrophied tissues around the "real" mouth. At the same time, the esophagus is elongated so that the real mouth is situated at the end of the proboscis sheath. *Asterophila perknasteri* and *A. rathbunasteri* can retract at least parts of the proboscis into the stalk.

Asterophila japonica has a very short, sometimes almost non-existent proboscis (Grusov, 1965), but in *A. perknasteri*, the proboscis may be as long as the diameter of the body (when leading to the subradial canal, in small specimens even three times the body diameter), while in specimens attached close to the gonad, it may be very short. This discrepancy between *A. japonica* and *perknasteri* may have been caused by the fact that specimens of the former species, with a long proboscis, had been damaged when removed from the host and/or that Grusov's observations of the proboscis were based on specimens with an unusually short proboscis. We find it likely that the length of the proboscis to some extent is individually adjusted by growth (since there are no internal retractors; Grusov, 1965:127) to the position of the snail in relation to suitable food sources.

The snails are assumed to feed by pumping body fluid from the host, usually from the subradial canal. This fluid is taken directly into the digestive gland, which is covered by the gonad.

Both large and small specimens have a well-developed pseudopallial pore forming a communication to the surrounding sea. Possibly this gives some clues about its evolutionary origin and function: It may be a rudiment of an evolutionary sequence, from shell-bearing ancestors sitting in a bowl-shaped depression in the external body wall of the host; and its present function in recently settled specimens may be to allow a larva to enter through this pore to become its mate. The presence of remains of one or two larval shells in the pallial slit of several small females of *A. perknasteri* with no egg mass or an egg mass in an early stage of development, supports this hypothesis.

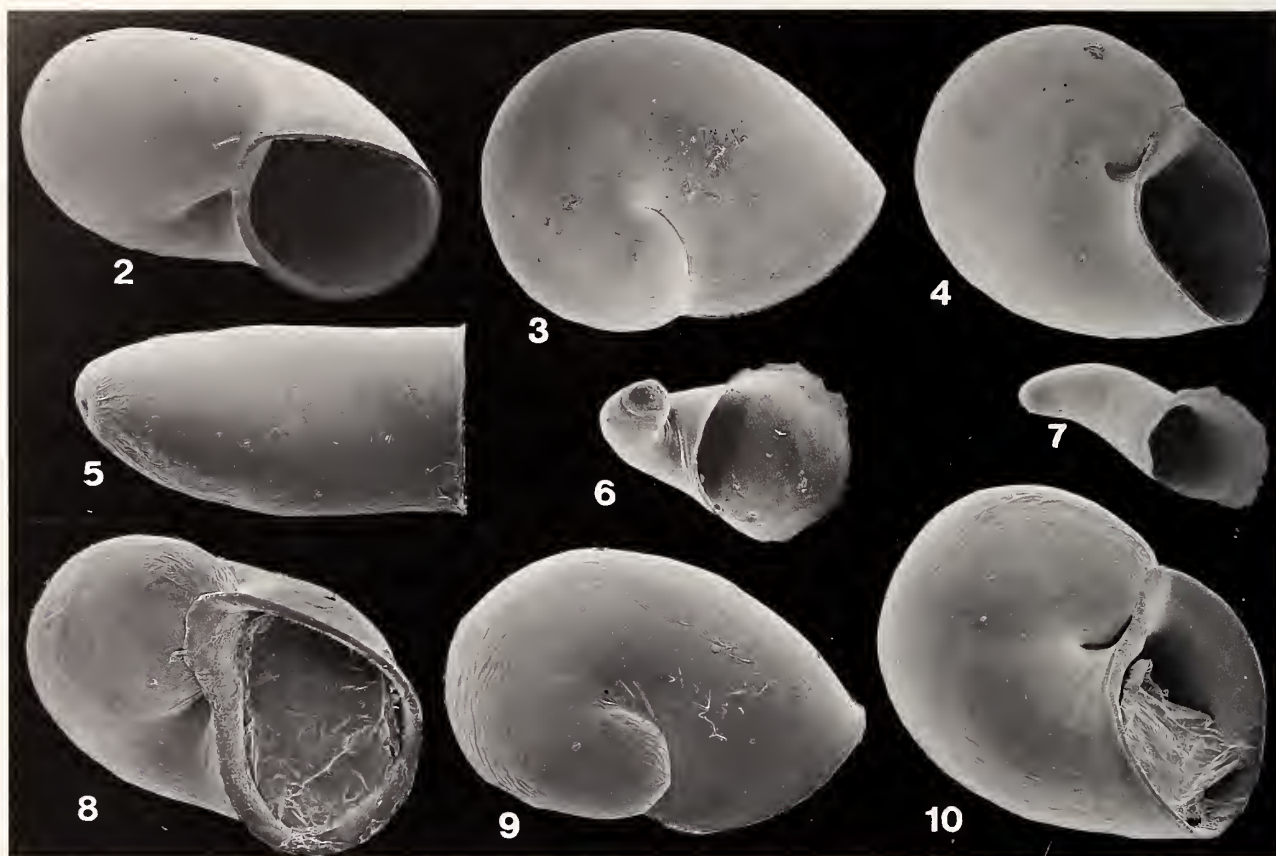
Small specimens, one-eighth to one-fourth of maximum size, have no egg mass, but larger specimens usually have one.

Many specimens of *A. perknasteri* and *A. rathbunasteri* with newly laid eggs in the capsule had a virtually empty visceral mass, which together with the fact that all eggs in an egg capsule are in the same stage of development, suggests that egg laying takes place during a short time. Other specimens with a large capsule full of seemingly mature veliger larvae had filled their visceral mass again with stored nutrients, suggesting preparations for the next spawning.

Nothing is known about the life span of the parasites, except that they evidently produce more than one brood of eggs.

Egg masses of mature specimens may contain from many hundreds in the smallest specimens up to several tens of thousands of eggs or developing embryos (in large specimens of *A. perknasteri*), and is evidently directly related to the body volume.

The larval shell (protoconch 1), which does not grow between the late larval stages in the egg capsule, and the empty larval shells found inside females of *A. perknasteri*, indicates lecithotrophic development. The morphology of the larvae (see Grusov, 1965) indicates that they have a



Explanation of Figures 2 to 10

Larval shells of *Asterophila* spp.

Figures 2–4. *A. perknasteri* Warén, sp. nov., diameters 690, 720, and 710 μm .

Figure 5. *A. rathbunasteri* Warén, sp. nov., abnormal larval shell, length 610 μm .

Figures 6, 7. *A. perknasteri* Warén, sp. nov., abnormal larval shells, length 690 and 900 μm .

Figures 8–10. *A. rathbunasteri* Warén, sp. nov., diameters 480, 515, and 500 μm respectively.

free-swimming dispersal stage, enabling them to find new hosts.

The youngest larvae with a shell are about two-thirds of the size of the mature larvae, and their shell includes only the first part of the final protoconch. Such larvae have a large and solid digestive gland, which evidently stores

nutrition and supplies material for further growth, since the digestive gland is smaller and less dense in the largest larvae. In each egg mass, the stage of development and size of the larvae are very uniform, except for scattered abnormal larvae (Figures 5–7). Such larvae are rare, occurring only in scattered females, but then usually several

Explanation of Figures 11 to 13

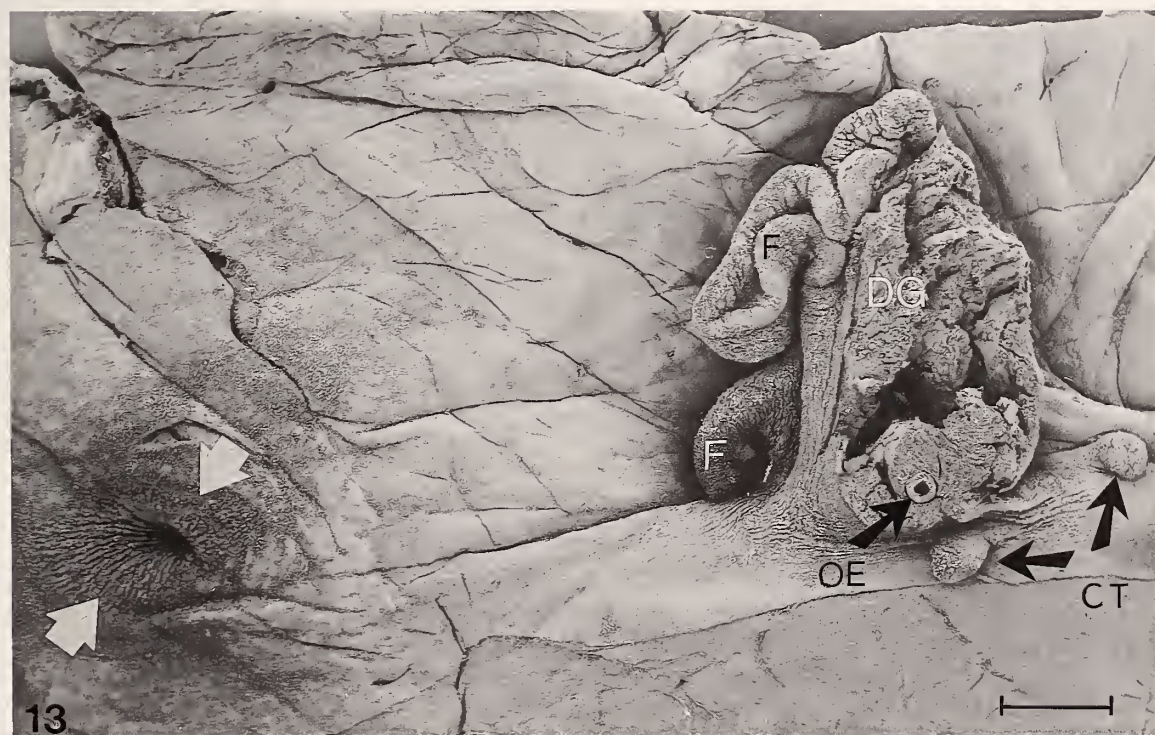
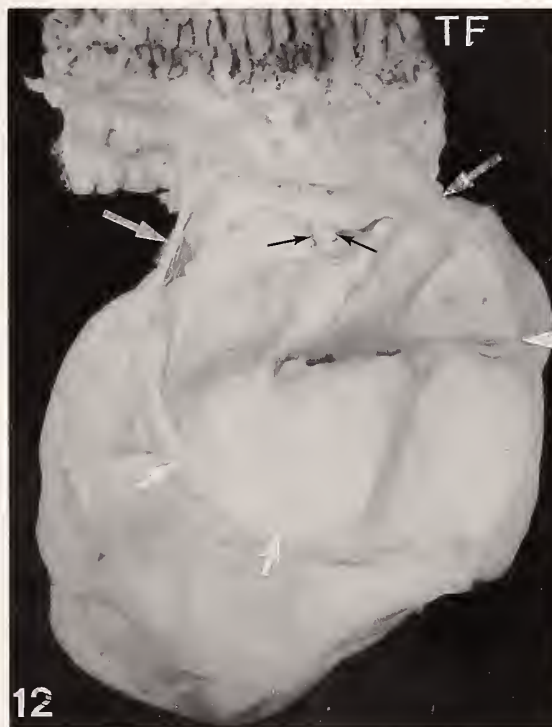
Asterophila perknasteri Warén, sp. nov.

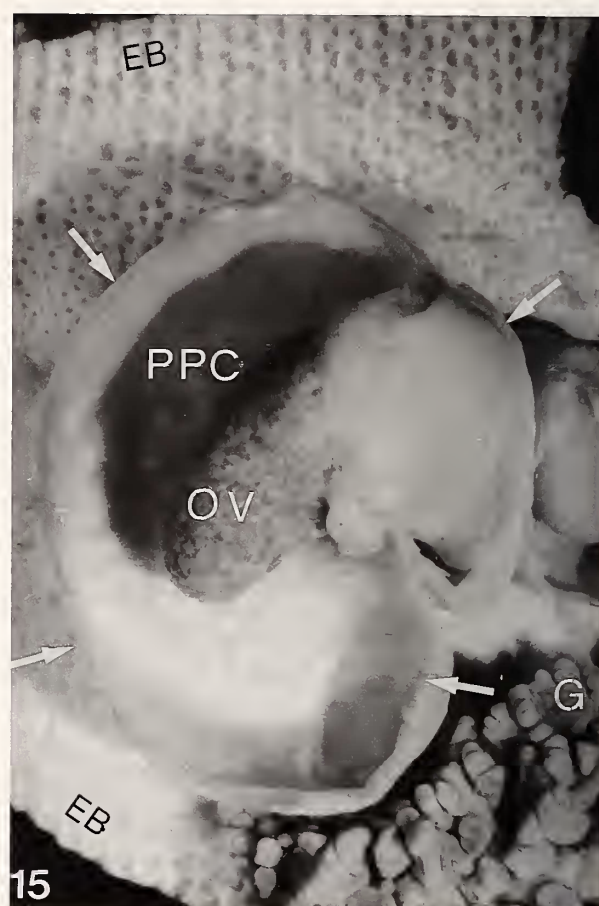
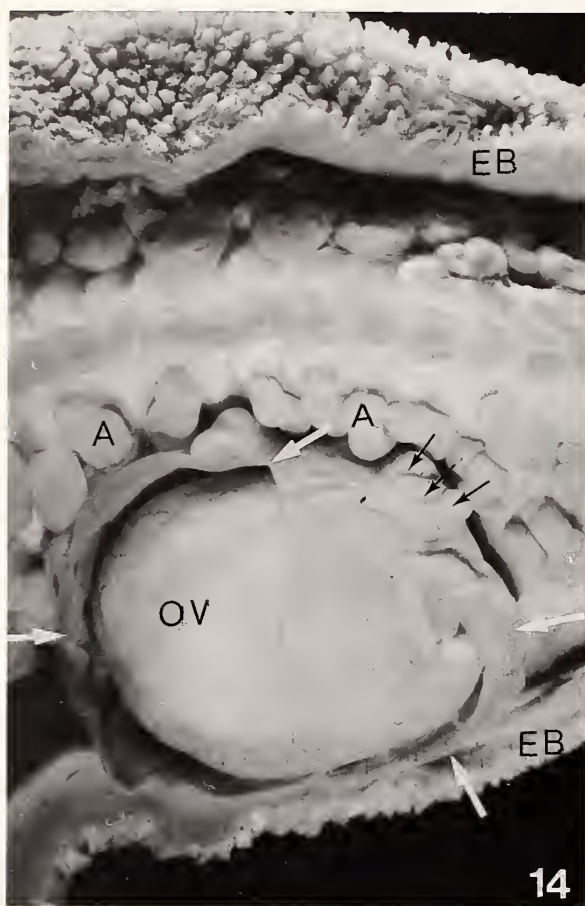
Figure 11. Piece of an arm of *Perknaster* sp., external view of the pore connecting to the pseudopallial cavity of the snail (indicated by two arrows). Scale line 3 mm.

Figure 12. Holotype, intact with a piece of the arm of the host. Maximum diameter of cyst ca. 30 mm. Coelomic epithelium of the host opened and indicated by white arrows. Proboscis indicated by two thin, black arrows.

Figure 13. Interior of the pseudopallial cavity of *A. perknasteri* Warén, sp. nov., showing the exit pore (marked with arrows) and stalk of the snail. The visceral mass has been removed to show the rudiments of the foot and the tentacles. Scale line 2 mm.

CT—cephalic tentacle; F—foot; OE—esophagus; DG—digestive gland; TF—tube foot.





Explanation of Figures 14 and 15

Asterophila perknasteri Warén, sp. nov. in *Perknaster* sp., from *Proantar*.

Figure 14. Specimen attached laterally on the ambulacrum. Pseudopallium (indicated with white arrows) opened to show the visceral mass of a specimen without an egg mass, presumably ready to form one. Some ampullae of the host (marked by black arrows) have been incorporated with the coelomic epithelium on the pseudopallium. Diameter of cyst 12 mm.

Figure 15. Specimen attached to the aboral body wall of host, close to the disc. The pseudopallium has been opened and egg mass removed to show the much smaller size of the visceral mass soon after spawning. Diameter of cyst 15 mm. A second much smaller specimen is visible at the right edge of the picture.

A—ampullae; OV—ovary of the snail; G—gonad of the host; PPC—pseudopallial cavity; EB—external body wall of the host.

deformed larvae. The uniformity in the development indicates that spawning is not continuous but takes place during a short time.

The size and structure of the larval shell is very uniform in the egg masses which have been examined within one host species: Mature stages of *A. rathbunasteri* measure 460–520 μm in maximum diameter and in *A. perknasteri* 650–750 μm . The size thus seems to differ between species, and can be used for species identification in these cases. Hoberg et al. (1980) reported an average size of the larvae of 0.48 mm (range 0.28–0.60 mm) in *A. japonica*. Grusov (1965:fig. 44) figured larvae with a maximum diameter of

0.36 mm, but mentioned a maximum diameter of the larvae of 0.57 mm (the same sizes given by Grusov, 1966:177). The large variation indicates that these figures probably include young larvae, and cannot therefore be used for comparison between different species.

Specific identification of species of *Asterophila* is difficult since the species have few comparable characters and usually are quite distorted by the contractions of the host asteroid when it was preserved. It seems also that the posterior part of the foot (when it is present) and the rudimentary appendages of the head and their position are quite variable.

Asterophila perknasteri
Warén, sp. nov.

Figures 2–4, 6–7, 11–15

Type locality: Antarctica, western coast of Graham land, *Hero* Cruise 824, station 24–1, 64°15.2'–64° 14.5'S, 61°27.5'–61°25.9'W, 540–605 m, in three *Perknaster* sp. (Valvatida: family Ganeriidae) with 6–8 parasites each. Collected by J. E. Dearborn and G. Hendler.

Type material: Holotype USNM 8603370 (Figure 12). Six lots in alcohol, from the type locality, each with one or several gastropods, plus one sample of dried and one of wet larval shells are all considered paratypes, USNM 860371–860377. Reference material of the host starfish is kept at the collection of echinoderms, USNM E43012.

Material examined: The type material and: *Proantar IV*, 02 February 1986, station 4865, 62°55.0'S, 55°16.5'W, 82 depth m, Antarctica, north of Joinville Island and north-east of Palmer Peninsula. 3 *Perknaster* sp. with many *Asterophila*. *Proantar IV*, 02 February 1986, station 4874, 63°25.8'S, 62°19.8'W, 135 m, 14 February 1986. Just southwest of South Shetland Islands. 2 *Perknaster* sp. with 4 *Asterophila*. *Proantar IV*, 02 February 1986, station 4875, 63°17.4'S, 62°30.2'W, 157 m, 14 February 1986. Just southwest of South Shetland Islands. 1 *Perknaster* sp. with 1 *Asterophila*. The specimens above were collected during the "Programa Antártico Brasileiro" (*Proantar*), during work carried out from "N.Oc. Prof. W. Besnard," and the specimens were forwarded by L. de Sigueira Campos. This material is now kept at the Oceanographic Institute of the University of Sao Paulo.

Description: The cysts (Figure 12, 14–15) are large, up to 30 mm diameter of the pseudopallium. They are situated in a large blister between the body wall and coelomic epithelium of the host, bulging into and partly filling the coelomic cavity of the arms. The proboscis leaves the pseudopallium and runs just under the coelomic epithelium, usually toward the ambulacrum, enters a tube foot and continues via this to the subradial canal. In dorsally attached specimens, the proboscis runs for a long distance through the body wall, but it was not possible to find its end in such specimens. On the inside of the pseudopallium, a few millimeters from the stalk, two conspicuous small bulges represent the cephalic tentacles (Figure 13:CT). Some distance behind the stalk and somewhat to the right is a pore in a thickened part of the pseudopallium (Figure 13: white arrows), usually corresponding to a bowl-shaped impression in the body wall of the host. This impression sometimes has a pore opening externally on the body wall of the host (Figure 11). The thickened part of the pseudopallium is evidently muscular, since it has a system of concentric and radial ridges surrounding the opening. The rudimentary and distorted foot (Figure 13:F) is situated on the right side at the transition from the stalk to the

visceral mass. Its anterior part is tonguelike and free. The posterior part has a poorly defined system of furrows and folds, perhaps also involving opercular lobes. At the anterior right side of the stalk, one specimen has a triangular process, possibly a rudimentary penis. Some specimens have additional little bumps at the anterior part of the stalk, possibly additional cephalic tentacles. The right corner of the pallial cavity is swollen and solid, and seems to be a partly evaginated pallial oviduct. Above the left part of this swelling starts a furrow which continues clockwise all around the stalk and joins itself above the posterior part of the swelling. This is the pallial margin. The pallial oviduct opens just inside the pallial cavity central to the swelling, but no groove could be traced from here to carry the eggs away. The basal third of the visceral sack contains the poorly discernable pericardium and kidney plus the digestive gland; the apical part contains the large gonad.

The egg mass is contained within a thin membrane which in turn is stuck to the visceral mass (but not to the pseudopallium) and has a volume up to twice that of the visceral mass. It is stored in the pseudopallial cavity apically and around the visceral mass. Large specimens have an egg mass containing more than 40,000 embryos or larvae. The average egg diameter is about 300 μm , and the final size of the larval shell (Figures 2–4) is about 720 \times 500 \times 400 μm . Examination of several thousand larvae of *A. perknasteri* from many females and measurements of all that were extra large or small showed a range of 650–760 μm .

The male was not found, but several small females with no egg mass or an egg mass containing only early cleavage stages had one or two empty larval shells (usually partly dissolved or resorbed) stuck in the pallial slit, and it is assumed that the male is attached in the pallial cavity or inside the oviduct. The smallest ovigerous female was 2.8 mm in maximum diameter of the pseudopallium.

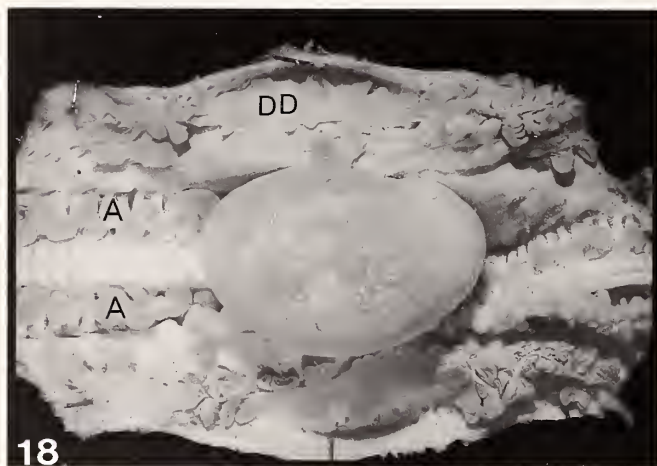
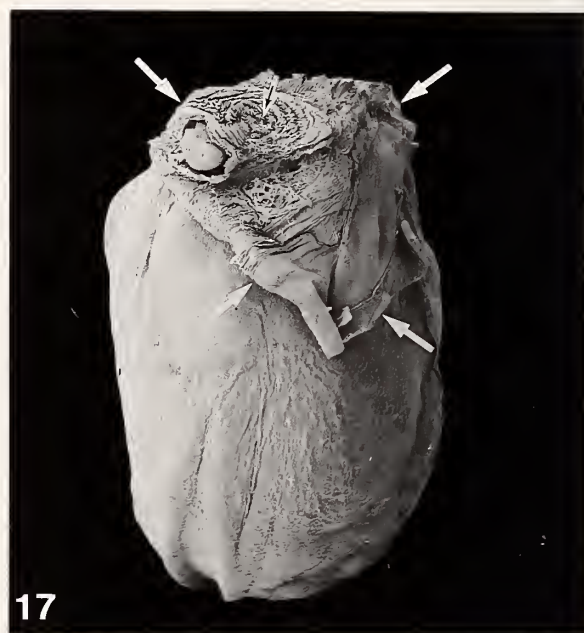
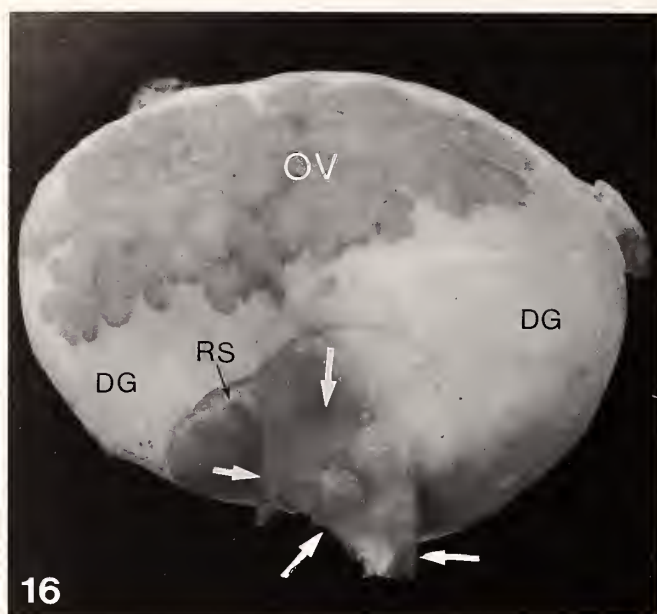
Remarks: The gross organization of *A. japonica* and the specimens above is similar in most features, but the detailed anatomy of the reproductive system remains to be compared. This would have required serial sectioning of a couple of mature specimens, work we did not consider necessary to diagnose the present species.

The presence of empty larval shells, the absence of an externally visible receptaculum seminis, and absence of externally situated males seems enough evidence to assume that the males are internal in the female and probably living parasitically in her oviduct.

A comparison with *Asterophila japonica* shows the following differences:

1. *Asterophila japonica* has one or several males attached externally on the pseudopallium, close to the pseudopallial pore, while we presume *A. perknasteri* to have internal males.

2. *Asterophila japonica* has larvae of a maximum diameter of about 600 μm , while those of *A. perknasteri* are



Explanation of Figures 16 to 19

Asterophila rathbunasteri Warén, sp. nov.

Figure 16. Visceral mass, weakly stained with karm-alum. The pseudopallium has been removed, except a small area around the stalk, marked with white arrows. The two top and left of these are placed on the darkly staining pallial oviduct, where the receptaculum seminis just barely can be seen. Maximum diameter of visceral mass 12 mm.

Figures 17, 19. Critical point dried female with its dwarf male. Most of the pseudopallium has been removed, the remaining part indicated by white arrows. The shorter black and white arrow

indicates the pseudopallial pore. 19. Detail of Figure 18, showing exterior of pseudopallium with a male (demarcated by white arrows) and the pore (marked by a larger arrow). The pseudopallium of the male has been opened to expose the visceral mass.

Figure 18. Intact holotype in arm of *Rathbunaster californicus*. Length of cyst 13.5 mm.

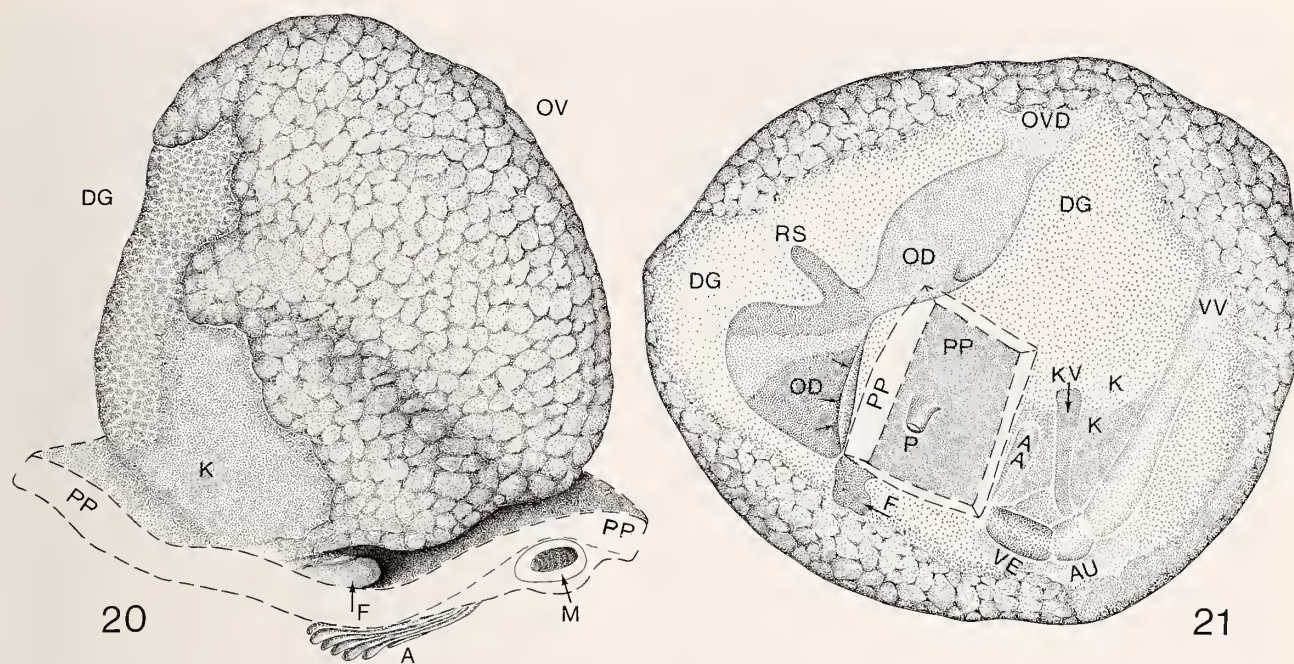
A—ampullae; DD—digestive diverticulæ of starfish; DG—digestive gland; OV—ovary; PP—pseudopallium; VM—visceral mass; RS—receptaculum seminis.

about 650–760 μ m. Furthermore, the ratio between the largest and smallest diameter of the larval shell is 1.8 in *A. japonica* but 1.5 in *A. perknasteri*.

3. Grusov (1965) did not mention the presence of rudimentary tentacles in *A. japonica*, nor are they figured in

his excellent and detailed drawings. These tentacles are conspicuous in *A. perknasteri*.

The host starfish could not be determined specifically, but if a need arises, there are voucher specimens of the host in USNM (see "Type material").



Explanation of Figures 20 and 21

Asterophila rathbunasteri Warén, sp. nov., visceral mass. The pseudopallium has been removed, except around the stalk. Diameter of both specimens ca. 5 mm.

Figure 20. Lateral view, showing the very small rudiment of the foot, the position of the male, and a strongly folded ampulla, incorporated with the coelomic epithelium around the pseudopallium.

Figure 21. "Front view," showing most of the internal organs

by transparency. The pseudopallium has been removed except for a square piece around the proboscis.

AA—anterior aorta; AU—auricle; DG—digestive gland; F—foot; K—kidney; KV—kidney vein; M—male cyst; OVD—ovarian duct; OD—glandular oviduct, opening in a narrow slit marked with 3 arrows; P—proboscis; PP—pseudopallium; RS—receptaculum seminis; VE—ventricle; VV—visceral vein.

Asterophila rathbunasteri
Warén, sp. nov.

Figures 5, 8–10, 16–21

Type material: Holotype, USNM 860366, numerous paratypes in USNM. Additional voucher material deposited in Los Angeles County Museum of Natural History.

Type locality: Off California, Monterey submarine canyon, ca. 36.5°N, 122.2°W, depth about 250–650 m. Parasitic in *Rathbunaster californicus* Fischer, 1906 (Forcipulatida, family Asteroiidae). Collected by L. Lewis and J. Nybakken, from June 1990 to November 1991.

Description: Cyst (Figure 18) globular to bean-shaped, up to 13 mm maximum diameter. The stalk is very short, with the anterior part of the foot (Figure 20:F) protruding like a small tongue, directly above the pseudopallial pore. The posterior part of foot could not be found. There are no tentacle rudiments. The pseudopallial pore (Figure 17) is small, with a thickened and ridged area around it.

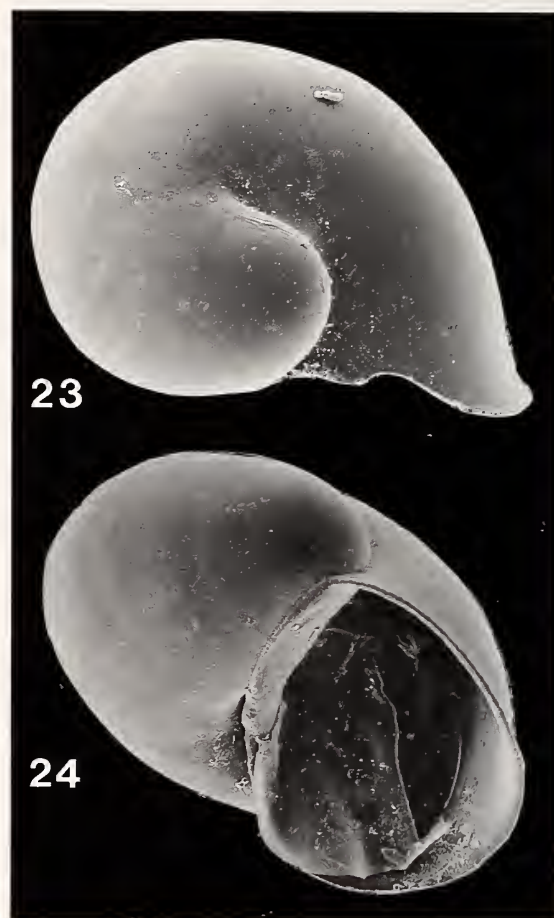
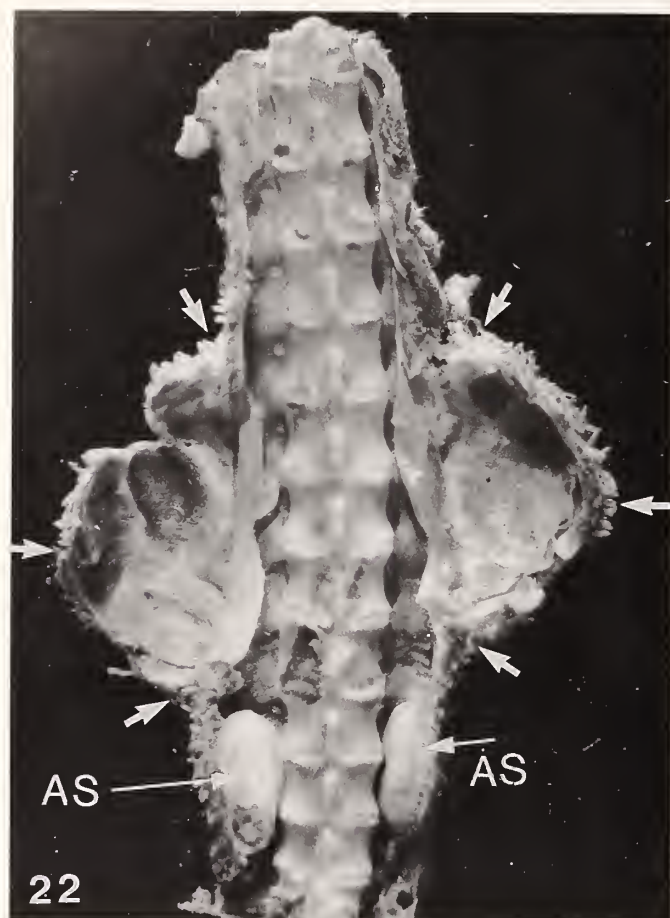
The pseudopallial pore in females with mature veligers is resting in a depression in the body wall of the host. In one specimen still *in situ*, it communicated with a duct into

a papulum (dermal gill), and could be followed with an eyebrow hair to the distal part of the papulum. This duct appeared to open through the papulum.

Juvenile specimens (cyst diameter 2–3 mm) have a more prominent pore than adults, and it is possible that the young male enters through a pore that the female has made in the skin of the host.

The oviduct (Figure 21:OD) is lying superficially and is bright, opaque, snow white. Its shape is highly variable, but usually divided into two parts by a constriction where the receptaculum seminis is situated. This is a club-shaped appendix also lying close to the body wall, directed apically at a right angle to the length axis of the oviduct. The oviduct is lying in a half circle close to the stalk. The distal part opens via a narrow slit, a vestigial pallial cavity, close to the reduced foot. Clockwise from the constricted part of the oviduct is the albumen gland, which is connected to the large ovary via a superficial and thin-walled ovarian duct.

The proboscis sheath is very short, but it is not known how much this is caused by contraction. It is muscular, and in one specimen, it was completely retracted, lying inverted into the cephalopodal haemocoel. In other spec-



Explanation of Figures 22 to 24

Asterophila sp., in *Freyella* sp.

Figure 22. Opened arm of the host starfish with cavities (demarcated by arrows) from two specimens of *Asterophila* sp. Distally (below) to these are two specimens of the ascothoracid *Bifurgaster kermadeca* (Stone) (arrows "AS"). Length of opened arm 17 mm.

Figures 23, 24. Larval shells, diameter 0.6–0.7 mm.

imens, the proboscis sheath ended at the dermal skeleton of the host, which was penetrated by a thin canal leading to the cavity of a tube foot.

The egg mass occupies most of the space in the pseudopallial cavity and is contained by a thin membrane. It contains up to about a thousand eggs or embryos. Some females have large quantities of "yolk" surrounding the embryos. The diameter of uncleaved eggs is 250–300 μ m. In any one female, all larvae are in the same stage of development, but this stage can vary between different females in the same host, suggesting that there is no seasonality in reproduction, only individual periodicity.

The larvae start to form a shell (which then is extremely thin and fragile) at a diameter of about 400 μ m. Mature larvae (Figures 8–10) measure 460–520 μ m in diameter (largest and smallest from several females measured).

The male (Figures 17, 19) lies in a cyst in the pseudopallium, close to the pseudopallial pore, and communicates with the pore via a duct in the pseudopallium. The

body of the male consists of a visceral mass, 0.5 mm in diameter, and a rudimentary foot about 0.2 mm broad and 0.5 mm long. The duct evidently transports sperm to the pore, from where it may then be transported by the anterior part of the foot of the female which is situated close to the opening of the pallial oviduct. The inside of the male duct and the pore absorb karm-alum dye more readily, while the interior of the wall of the pseudopallium hardly absorbs it at all. This is a good indication that some activity unusual for the pseudopallium takes place there.

Remarks: *Rathbunaster californicus* is a large asteriid starfish with 8–22 arms. It is known from the American west coast, from southern Alaska to Monterey Bay in California, in depths between 60 and 1000 meters. It is a benthic predator and scavenger with ability to catch mobile benthopelagic prey (Carey, 1972; Lewis, unpublished thesis). Five hundred host starfishes from several sites in the Monterey Bay were examined externally to determine the local

prevalence. This was found to vary between 0 and 59 percent of the hosts. These figures are, however, too low because dissection of 50 starfishes usually doubled the rate obtained from external observation.

The number of parasites per host starfish was usually more than one at the richer localities, which means that the snail was several hundred times more common at some localities compared with the poorest ones. Up to six snails could be found in a single arm, and the maximum total weight of the snails from one host corresponded to 13.8% of the body weight of the host.

Attempts were made to determine whether the starfishes were harmed by the parasitic snail, by comparing the gonads between parasitized and unparasitized individual arms and starfishes, but no significant average difference was detected. However, gonads were missing in one arm with six snails and one arm with five snails (four and three cases, respectively, were examined). This was otherwise a rare phenomenon (Lewis, unpublished thesis).

The detailed internal organization of the visceral mass was not examined; this would have required histological sectioning. The intentions were to describe the external morphology in enough detail to allow recognition of the species.

A comparison with *Asterophila japonica* shows a single major difference: The male is lying embedded in the pseudopallial wall in *A. rathbunasteri*, attached externally in *A. japonica*. There may be other differences, e.g., in the larval shell, but that has been described too incompletely in *A. japonica* to allow comparison.

Asterophila rathbunasteri differs from *A. perknasteri* in the size of the larval shell which is 460–520 μm and completely smooth in *A. rathbunasteri*, 650–750 μm and slightly “wrinkled” in *A. perknasteri*. *Asterophila rathbunasteri* differs also by lacking rudimentary tentacles, having the male living in the pseudopallium (position not known but absent in pseudopallium in *perknasteri*), and by having a more reduced foot.

Asterophila sp.

Figures 22–24

Material examined: From *Freyella* sp. (Brisingida: family Brisingidae), southern part of the Kermadec Trench, *Galathea* Expedition, station 661, 36°07'S, 178°52'W, 5480 m depth, 23 February 1952. 3 specimens of *Asterophila* found in two hosts, in connection with work on endoparasitic ascothoracids (Crustacea), by C. Stone (Stone & Moyse, 1985). The specimens were already dissected when sent to Warén, and only scattered notes on various features could be obtained. This material is now kept in the Zoological Museum of the University of Copenhagen.

Remarks: The specimens were in poor condition, and the limited material does not allow comparison with the other species.

Two specimens were sitting in galls in the body wall,

covered by the coelomic epithelium in one arm. A single specimen in another arm was situated in the same way. The diameter varied between 4 and 7 mm. Only one of them had veliger larvae (Figures 23–24), two of which still were intact when Warén received the specimen used for SEM. They had a maximum diameter of 600–700 μm . In the arm with a single parasite, the proboscis was found, directed toward the ambulacrum. The other two galls also had holes directed toward the ambulacral system, which may have been caused by proboscides. No males were found. No tentacles were seen in the remains of the pseudopallium. The pseudopallial pore was surrounded by concentric muscular ridges and was situated apically in one specimen, laterally in the second, and had been lost during the dissection of the third.

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